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To Support Complex, Dynamic, Distributed Decision Making for Emergency Management in Large Organisations

The ISEM-Group

prepared by V. Andersen, H.B. Andersen, E. Axel, and T. Petersen

Risø National Laboratory, DK-4000 Roskilde, Denmark
January 1990

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DEVELOPMENT OF A DESCRIPTIVE MODEL OF AN INTEGRATED INFORMATION SYSTEM TO SUPPORT COMPLEX, DYNAMIC, DISTRIBUTED DECISION MAKING FOR EMERGENCY MANAGEMENT IN LARGE ORGANISATIONS.

The ISEM-group(*)

prepared by V. Andersen, H.B. Andersen, E. Axel, and T. Petersen.
Risø National Laboratory, DK 4000, Roskilde, Denmark.

ABSTRACT

A short introduction will be given to the European (ESPRIT II) project, "IT Support for Emergency Management - ISEM".
The project is aimed at the development of an integrated information system capable of supporting the complex, dynamic, distributed decision making in the management of emergencies.
The basic models developed to describe and construct emergency management organisations and their preparedness have been illustrated, and it has been stated that similarities may be found even in emergency situations that originally are of quite different nature.

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1. Introduction

The potential risk of critical situations at industrial plants, still increasing in size, has drawn increased attention to emergency organisations coping with such situations. Experience gained from previous incidents and emergency drills has revealed the complexity that must be faced in making these organisations work properly. A well-functioning preparedness system puts heavy demands on communication, the accessibility of knowledge, conditions of competence, and decision making.

Two of the more often quoted cases of nuclear accidents are the Three-Mile Island accident in the United States in 1979 and the Chernobyl accident in the Soviet Union in 1986.

The potential risk and emergencies caused by the chemical industry has been revealed clearly by the Bhopal accident in India, the Seveso accident in Italy, and the pollution of the Rhine caused by the fire at Sandoz in Switzerland.

In process industries of various types, there are a number of similarities in the potential emergencies. Some of the subsystems and components in the processes are very similar; thus their failure mechanisms can also be similar. Partly the similarities is due to the fact that most process industry plants have fairly large amount of energy and chemicals stored in the processes, and in the emergency their effect may be spread outside the plant itself.

In order to develop a general integrated decision support system for these situations, using modern information technology for support of emergency management, there is an interest to identify common characteristics of emergencies in various applications. The following list attempts to summarise some of the similarities

- the systems are complex,
- there are several different organisations involved,

- managing the emergencies needs efficient communication,
- the emergencies evolve in real-time.

The emergencies that could be considered may include emergencies of several types. In the proposal of the ISEM project three demonstrations were suggested:

- in the service industry in relation to large computer facilities including complex networks,
- in a hazardous chemical industry with potential release of toxic substances, and
- in a nuclear power installation with potential release of radioactive material.

Due to budget limitations it was decided to focus on the first and the latter.

Nevertheless, as market related information was analysed in more detail, it seemed that the service industry is not sufficiently matured in its present form to benefit from a comprehensive IT supported management system. Therefore, the project has turned to the chemical industry from which a great deal of interest has been received, and the direct target for ISEM will be industries where high concentrations of energy and/or chemicals can be the basis for major and hazardous releases with a resulting threat to human lives and property.

However, a different new potential area of interest in the service industry may show up following the on-going internationalisation of large co-operations, accompanied by a new distribution of work among the various geographically distributed operating units. As a consequence of this some thoughts concerning the service industry have been presented in this report to show the similarities between the service industry and the process industry in relation to emergency management.

Specific examples in the service industry where emergency management could be useful in the future are banks and insurance companies. This group has been alarmed about the disclosure how easy it seems to be for unauthorised people to manage to access even sensitive data bases or programmes. As one of the aims of the project is to reason about, e.g., incoming informations from sensors, the results from these tasks may be exploited as tools to raise the security and safety of data processing environments by protecting them against access of unauthorised users. From the well understood habitude of these unauthorised users their effort to access the systems can be discovered in a similar way to the discovery of faulty sensor data.

So, it seems - and will be further investigated in this project - that similarities may be found even in emergency situations that originally are of quite different nature.

Furthermore, experience in nowadays severe accidents shows that emergency situations that previously were expected to be of local nature are now crossing national borders and having an influence several hundred kilometres from the source. Hence it seems rational to introduce joint international efforts in developing systems able to support emergency management. On this background the ISEM project has been started in January 1989 in the framework of ESPRIT2. It is partly based on a Nordic program, NKA/INF[1)].

2. User requirements for an emergency management system

For all emergency management systems user requirements may be specified in a common way. The system shall:

- collect the measurement data that are needed and useful,
- keep records of the present state of the system,
- give useful information about the current state and on the level of service offered by the system,
- keep a record of the recent action that might not yet have visible effects due to delays in the processes being observed,
- reach the right organisations in the intended order,

- produce guidance for the operator and the decision-maker,
- help to co-ordinate actions,
- monitor the plans and actions to determine how well actions follow the plans,
- provide support for reaching consistency of decisions,
- adapt dynamically to the current situation,
- remind the operator periodically to check the situation and trends at critical parts,
- be able to trace the arguments behind each action it suggests,
- include preparedness plans,
- include access to existing customer's data bases or other relevant data bases available.

Even if we benefit from the similarities in emergency situations, each emergency system developed should - to give the highest efficiency - be adapted to a given type of an emergency.

Aiming for this, the main features to be developed will be an Application Generator presenting a set of more or less fixed procedures and software tools for generating a distributed decision support system as an ISEM end product. Within the Application Generator an organisational model and an information flow model are the basis for the construction of the support system. A model of the Application Generator is shown in Figure 1.

3. The Application Generator.

The Application Generator is expected to be one of the main products of the ISEM project. It is partly a software product that consists of an "Emergency Management Knowledge Base" and software tools for two distinct categories: (1) "System Building Tools" for the purpose of producing emergency management systems, and (2) "End Product Tools" which are incorporated in the Emergency Management (EM) system to support the user of a system that has been produced by the Application Generator.

An overall view of the Application Generator is given by the illustration in Figure 1, which combines input from VTT, ADV/ORGA and Risø, (see the list of the ISEM-group). This indicates the final Application Generator used by the knowledge engineer developing an emergency management system for a specific customer. By use of the two sets of tools, the "System Building Tools" and the "End Product Tools", combined with the "ISEM Emergency Management Knowledge" the Application Generator will be capable of turning user requirements into an Emergency Management system for a given application and a given country.

The intention is to learn from each emergency management system being built by adding new and suitable information to the "ISEM Emergency Management Knowledge" base. The type of information used for this purpose will be specific requirements from the actual customer that have proven to have general value, and as such might be usable for later development of emergency management systems. Nevertheless, the basic tools to be included in the Emergency Management Knowledge will be an "Organisational Model" and an "Information Flow Model" developed in the ISEM project. The following section will be concerned with the organisational model, which is used to specify the agents to be involved in an emergency situation, how to organise the agents, and how to specify the tasks they have to perform.

4. Description of the ISEM Organisational Model

An overview of the ISEM organisational model has been given in Figure 2. This Figure indicates different levels of generality: The generic chart, the charts of classes, and the charts of particular instances. Each level represents a description of the organisational model, the upper levels having a more general validity than the lower ones.

The generic representation at <u>the top level</u>, illustrated in Figure 3, determines the relevant concepts of identifying an emergency management organisation in general terms, including open lists of goals and extent of authority, respectively. This description is meant to cover all possible kinds of emergencies.

The two charts at the middle level represent descriptions of classes of emergencies. It is suggested that the organisational set-up for emergency management can be divided into classes by the goals involved and by the extent of authority of the organisational units involved.

We have found that the organisational set-up for emergency management in process industries, exemplified by Nuclear Power Plants, is characterised by

- the goals involved: economic operation, plant integrity, and public protection,
- the extent of authority involved concerning: on site, off site and national. These levels may even be extended by a regional and/or an international level.

We have designed a chart to represent this class of organisational set-up's, see Figure 4.

We have likewise found that the organisational set-up for emergency management in service/network industries is characterised by

- the goals involved: economic operation, protection of installation systems, of the company, and of conservation of customer confidence, respectively.
- the extent of authority involved concerning: installation system, company on site, off site environment, and national environment.

We have designed a chart to represent this class of organisational set-up's, see Figure 5.

As indicated in Figure 2 more classes may be imagined, but we will exemplify only by the two classes mentioned above, covering the two applications originally focused upon in the objectives of the ISEM project.

The lowest level represents particular organisations of emergency management within each class. For the class of process industries the emergency management for nuclear power plants in different countries has been taken as examples. For the class of service/network industries four different kinds of emergency situations in computer centres have been chosen for illustration. For each particular organisation the procedures and the pattern of activation of the organisational units are specific. Many more particular organisations of emergency management within each class could be described.

The above mentioned examples have been used to demonstrate how well existing organisations fit into the developed organisational model. However, they have not been included in this paper but may be found in the first deliverable, D1, of the ISEM project[2)].

4.1 The ISEM Organisational Model for specific classes

Before we spell out the features of the model it is important to point out that it serves three purposes:

- First, it is intended to represent explicitly, when filled out in detail, the concrete EM organisational set-up, and escalation of EM activity for a particular plant or computer centre.
- Secondly, it is intended to be used - as we have done - as a means of identifying the general and specific functions which each organisational unit must fulfil during an emergency.
- Thirdly, it is intended to be used as a stepping stone towards representing the required flow of information among units at different stages of an emergency. The last objective is now explicitly addressed by the information flow model which was proposed by ENEA. This model is briefly presented below.

Referring to the charts of classes, Figures 4 and 5, the following concepts will be clarified: "The goals" and "The extent of authority".

<u>The goals:</u> These are stated at the top of the chart. The particular set of goals define, we suggest, a class of emergencies. So, any process industrial EM is defined by the three goals indicated: Public protection, Plant integrity, and economic operation; and similarly any service/network EM is defined by the goals: Protection of customers confidence, of the company, of installation, and of economic operation. The shaded areas of the horizontal goal bars represent the currently active goal. This does not mean that the overall importance of the goals change in time; it means that relatively more resources and attention are required to secure the currently active or currently top priority goal. So, for instance, the preservation of customers' confidence is of greater overall and long-term importance than the protection of a building - say, for a bank; nevertheless, the bank's EM organisation may at a given time during an emergency be quite rational in devoting much greater effort to protecting the building - merely because the goal of maintaining customers' confidence is not threatened at that stage.

The meaning of the distinction between passive and active protection of the public in the process industries is the following:

- The passive protection is the situation in which the public is not involved actively, but protected by actions of the emergency management organisation.
- In the active protection phase the public is actively involved by, e.g., orders to go inside, close their doors and windows, and listen to the radio. In a more severe situation the public will receive instructions for an evacuation.

The reason for distinguishing the active and the passive protection phases is that in the latter phase there is an enlarged risk that people will react non rationally. The similar phases for service EM - here described as company phase and customer phase - mean that only at the latter stage are the customers notified of the emergency and may therefore themselves initiate protective action or issue instructions to the company.

<u>The extent of authority:</u> This is indicated on the vertical axis. As the legend explains, the double-lined boxes are the units that at a given stage have the responsibility and authority within their "area" - either on-site, off-site, or nationally.

The following contains an illustration of the extent of authority combined with the escalation of activity among the units during a nuclear emergency, see Figure 4:

- In a normal situation the only active organisational unit is the control room staff, and the goal to be focused upon is the economic operation of the plant. During normal operation the process will be constantly watched by monitoring specific critical parameters.
- If one of these indicates an abnormal situation, the shift supervisor may be called and the responsibility will be passed to him. If needed, further technical expertise and managerial support from the plant owners' organisation may be brought in from outside the plant.
- If the situation evolves in an uncontrolled manner a site emergency management will be organised for an on-site emergency situation. Furthermore, the off-site local emergency organisation centre (EOC) will be notified. This centre will be responsible for the local off-site situation, while the responsibility for the operations at the plant still remains with the technical management of the plant. During the shift from one organisational set-up to the next the goal to be focused upon may shift from economic operation to plant integrity.
- If there is any risk of adverse consequences outside the plant as, for instance, toxic release, the emergency situation will change from site-emergency to general emergency. In the general emergency situation the organisation will develop concurrently

with the evolvement of the accident corresponding to the different columns in this phase. In this case the local EOC will build up an off-site organisation calling the necessary agents such as police, fire brigade, meteorological advisory service, etc.. The first action of the local EOC will be to assess the current state, both concerning the plant and concerning the local off-site environment, that is, weather conditions, population distribution, etc.. In this situation the goal to be focused upon will change from plant integrity into public protection - divided in passive and active protection, respectively, as explained above.

- The last column of the organisational chart indicates the recovery phase where the shift in goals means the return from focusing on the highest goal via the next, ending with the economic operation as the focused goal in the recovery situation.

4.2 Identification of general and specific functions

Each of the columns corresponds to a specific organisational set-up or configuration. So, at each stage of the emergency (at each column of the organisational chart) the entire emergency organisation has to fulfil the following general functions (or "general tasks"):

- assessment of the current state and current prognosis for the plant/environment,
- assessment and possible revision of the current priority of overall goals (which goals require relatively more attention and resources now?),
- assessment of the need for additional actions and agents: the decision to alert additional agents or organisational units,
- establishment of communication links with units and agents,
- distribution of tasks and the co-ordination of information needed to relevant units and agents.

The general functions outlined above may be seen as methods for the entire present organisation to define specific functions for each part (unit) of the organisation. This means that at a given time the specific functions will support fulfilment of the general functions.

Furthermore, the general functions will be means to decide upon the shift from one level of activity to the next. Generally speaking, the decision that additional units/agents are needed, means that next column of the organisational chart is entered. This may shift the current focused goal and it may shift the responsibility to a new unit.

It is important to realise that the time axis is not a simple linear one having equidistant time from one organisation to the next. Shift in organisation will depend on the specific situation including the escalation of the emergency situation and a decision taken by the actual organisational set-up.

Since the units and agents needed have been defined through these decisions, the nest step is to supply them with the tasks and information to perform proper actions. The description of these tasks is included in the information flow model presented in the next section.

5. The Information Flow Model

As the most important support offered by the emergency management organisation is the supply of relevant information to the relevant agents, the next task is to establish communication links corresponding to the current organisational configuration. For this purpose each organisational unit will be described in detail in a specific template including information about position in the hierarchy (responsibility), tasks to be performed, available resources, and form and content of communication with other units. Based on these templates the final information flow scheme may be developed.

Consequently, the information flow model consists of

- a format for templates for each organisational unit,
- a format for information flow charts,
- an accompanying set of definitions and explanations.

A complete flow chart will be rather complex and difficult to survey. Therefore, it has been decided to use different levels of resolution or details. These levels are called depth. At depth 1 we represent no further details than the undifferentiated layers of the EM organisation: organisations I, II, ... (see Figure 3) represented by the responsible unit for each extent of authority. At depth 2 the individual task units under the command of the responsible units are distinguishable, and at depth 3 the task units will be differentiated further into individual field units. Figure 6 gives an example of a flow diagram at depth 2 for a hypothetical emergency organisation using the agreed conventions concerning representation of names, responsible units, and informations.

6. Conclusion

A detailed description of the application generator as well as the models may be found in reference 2. These components will act as a basis for more profound analysis of user requirements as well as information technology needed for performing requirement specifications and implementation of the final ISEM product.

The results of this project is expected to be close to final products, and the number of European countries represented by at least one partner makes it possible to make the results available in many countries simultaneously. Furthermore, the composition of the consortium may initiate additional co-operation even after the project's termination, as the different experience and industrial interest of the partners might trigger such a co-operation in those cases when specific know-how is required that cannot be provided by that national partner but by one of the other partners.

7. References

1 The INF-group concerning the Nordic project and the ISEM-group concerning the European project, prepared by V. Andersen, project manager, Decision Support for Emergency Management, From the Nordic Project "NKA/INF: Information Technology for Accident and Emergency Management", to the European Project "IT Support for Emergency Management - ISEM", Risø-M-2788, 1989.

2 The ISEM-group, "IT Support for Emergency Management - ISEM", ESPRIT Project 2322, Deliverable 1, June 30, 1989.

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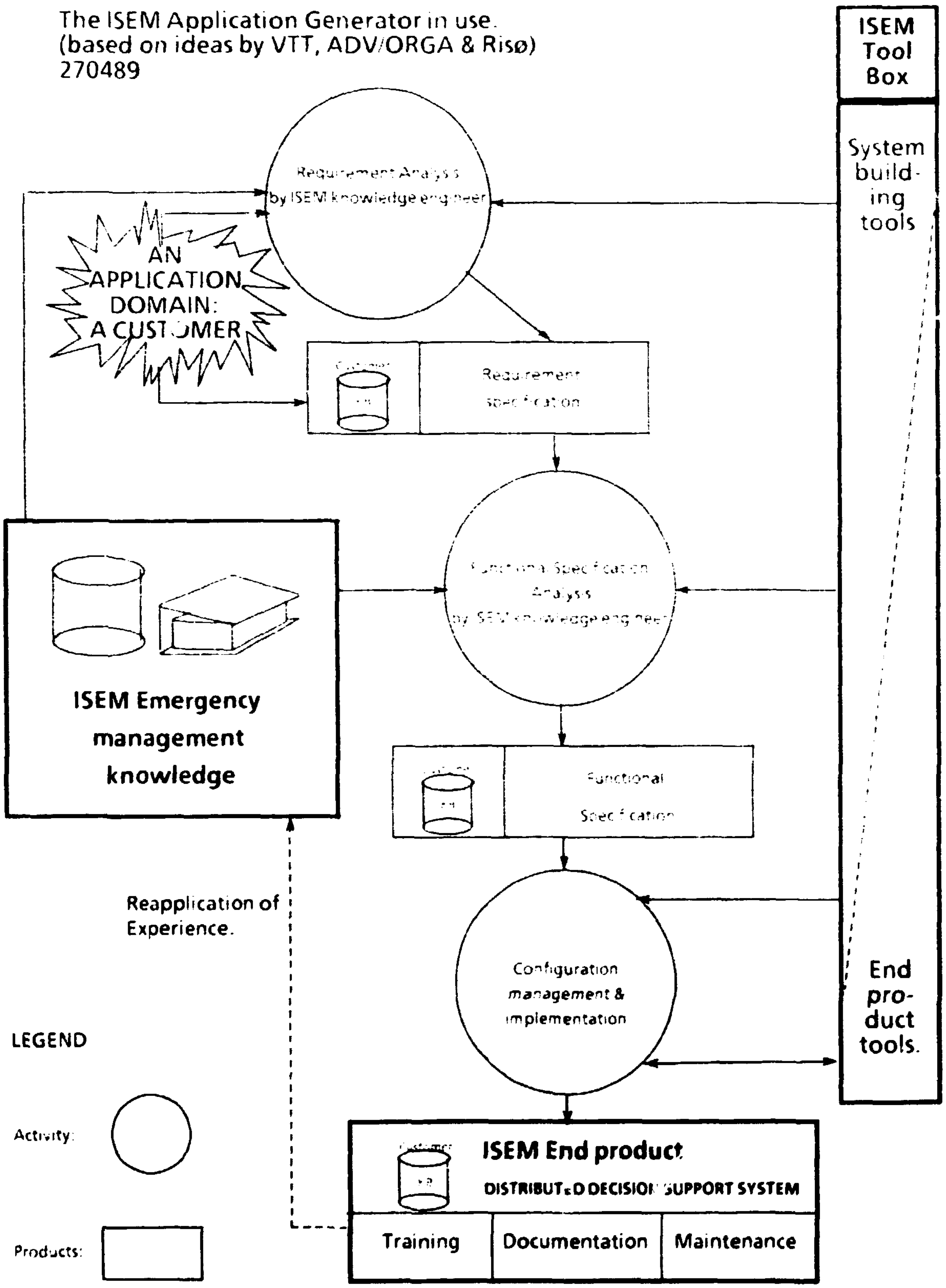

Figure 1: The Application Generator

<table>
<tr><th colspan="10">Overview of the Relationship Between Charts
of
Organizational Setup for Emergency Management</th></tr>
<tr><td>The generic chart:</td><td colspan="9">Development in time of organizational setup for Emergency Management.</td></tr>
<tr><td>The charts of classes:

Classes of organizational setup foremergency management</td><td colspan="4">The chart of
proces industrial
emergency management
setup</td><td colspan="4">The chart of
service/network
emergency management
setup</td><td>. . .</td></tr>
<tr><td>The charts of particular instances:

Particularorganizational setup for emergency management</td><td>Spain</td><td>Italy</td><td>Den-
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gency</td><td>Life
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Figure 2: Overview of the ISEM Organisational Model

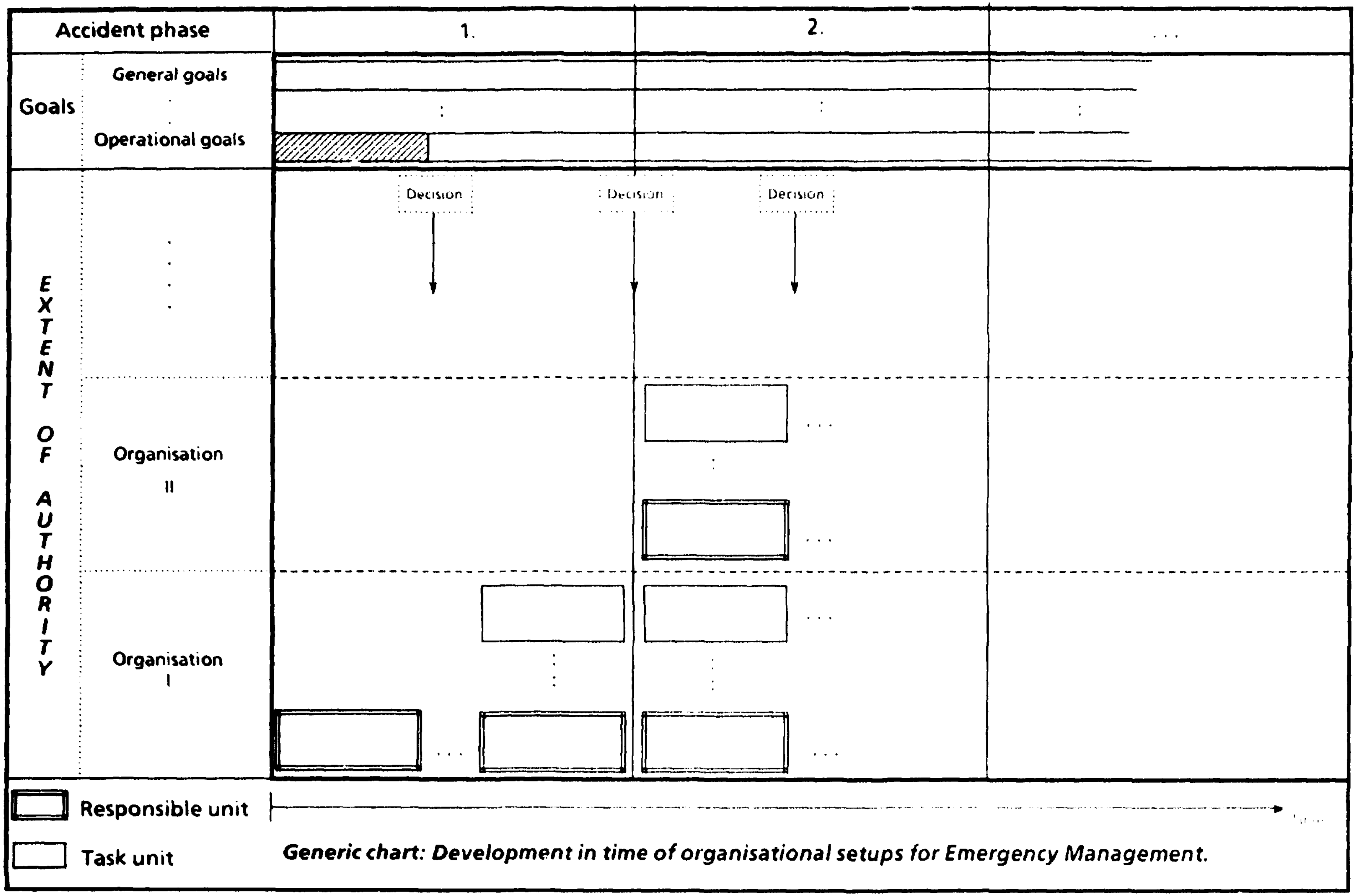

Figure 3: The Generic Representation of the Organisational Model

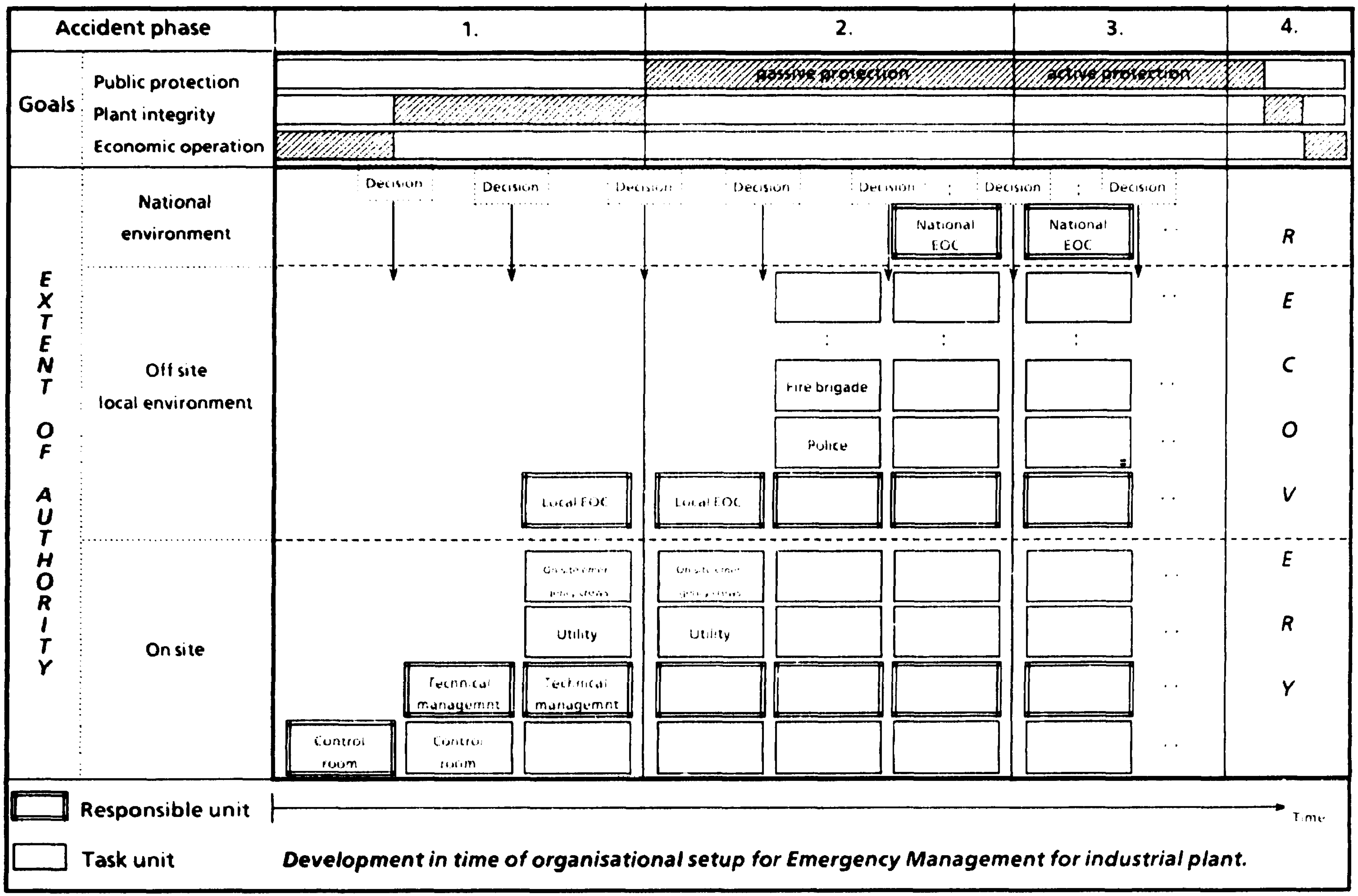

Figure 4: Generic Representation for the Process Industry

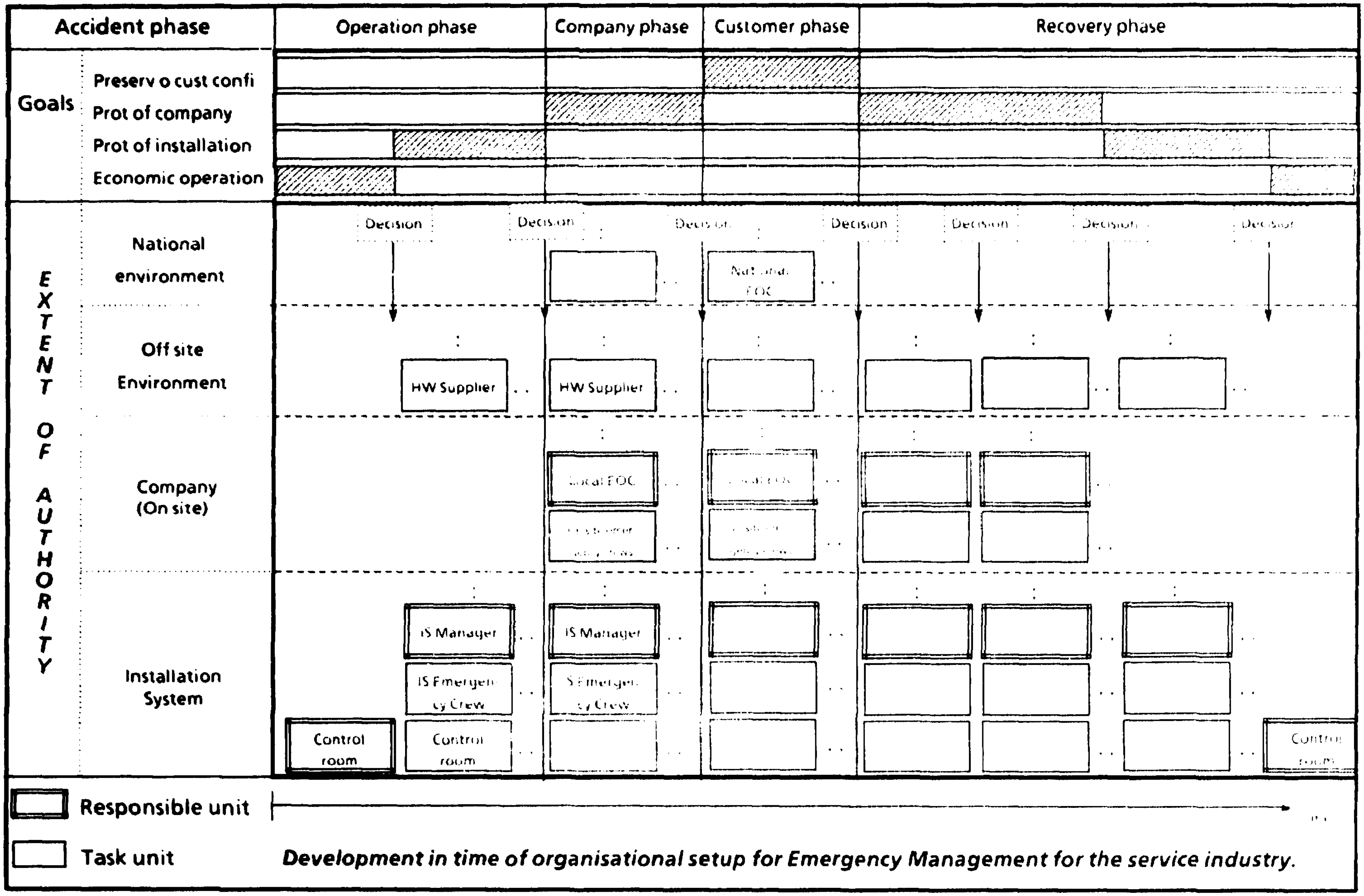

Figure 5: Generic Representation for the Service/Network Industry

Information flow diagram at depth 2:

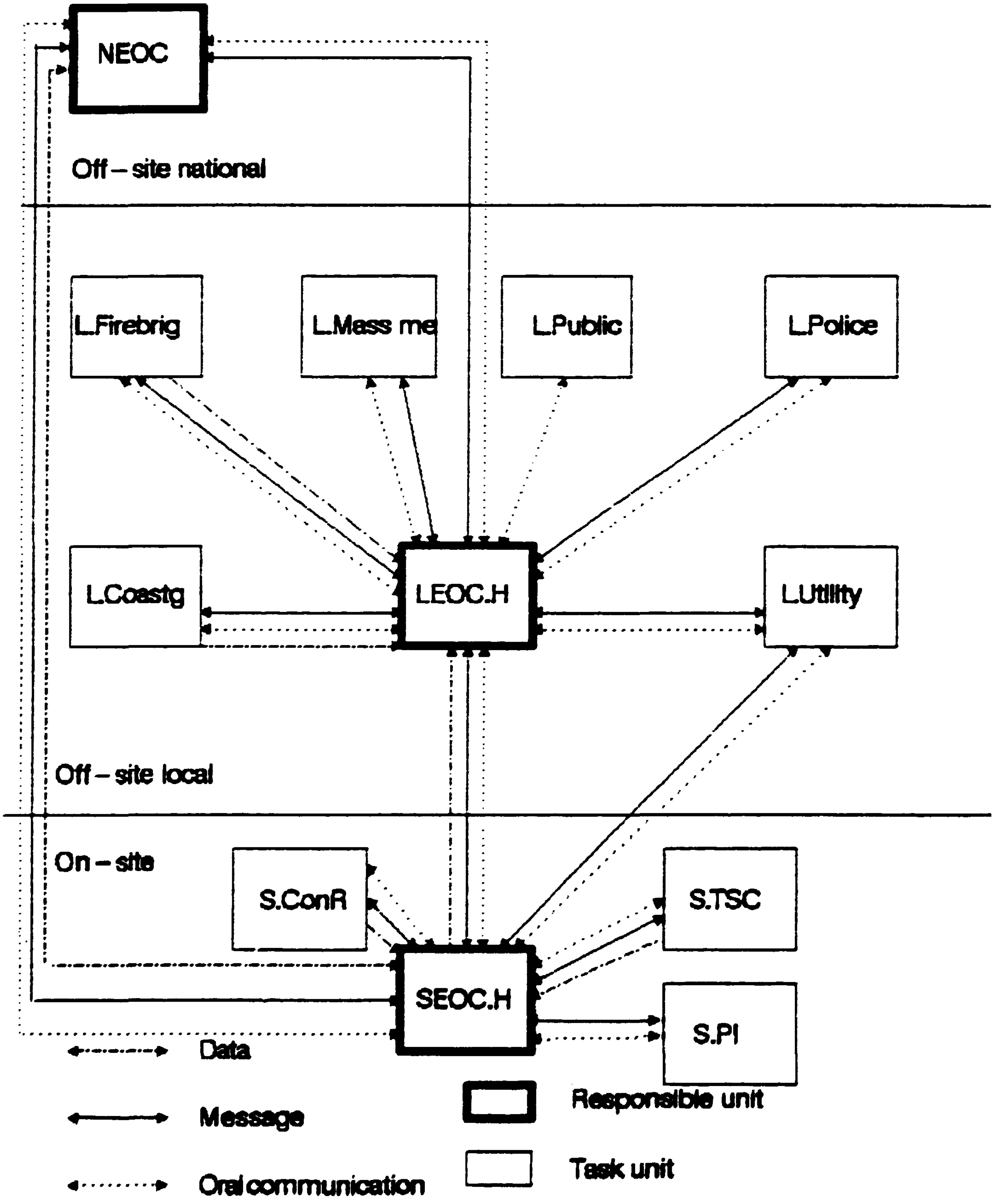

Figure 6: Example of Information flow diagram at depth 2

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